CBCS SCHEME

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21EC54

Fifth Semester B.E./B.Tech. Degree Examination, Dec.2024/Jan.2025
Electromagnetic Waves

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. If two position vectors $\overline{A} = -2\bar{a}_x - 5\bar{a}_y - 4\bar{a}_z$ and $\overline{B} = 2\bar{a}_x + 3\bar{a}_y + 5\bar{a}_z$ then find,

i) $\overline{AB}$ ii) $\bar{a}_A, \bar{a}_B$ iii) $\bar{a}_{AB}$ iv) Unit vector from C to A where C is (3, 5, 8) **(06 Marks)**

b. Ten identical charges each of 500 μc are spaced equally around a circle of radius 2 m. Find the force on a charge of – 20 μc located on the axis, 2m from the plane of the circle. **(07 Marks)**

c. Define Electric Field Intensity. Derive expression for electric field intensity due to 'n' number of charges. **(06 Marks)**

OR

2 a. Given the two points A(2, 3, –1) and B(4, 25, 120). Find spherical coordinates of A and Cartesian coordinates of B. **(06 Marks)**

b. Derive an expression for electric field intensity due to infinite line charge. **(07 Marks)**

c. Find electric field $\overline{E}$ at origin, if the following charge distribution are present in free space :

i) Point charge of 21nc at P(2, 0, 6)

ii) Uniform line charge of infinite length with charge density $\rho_\ell = 3$ nC/m at x = 2, y = 3.

iii) Uniform surface charge of density 0.2 nC/m^2 at x = 2. **(07 Marks)**

Module-2

3 a. A charge is uniformly distributed over a spherical surface of radius 'a'. Determine electric field intensity at all the places, use Gauss law. **(07 Marks)**

b. Evaluate both sides of divergence theorem for the field $\overline{D} = 2xy\bar{a}_x + x^2\bar{a}_y$ C/m^2, for a rectangular parallel piped formed by the planes x = 0 and x = 1 ; y = 0 and y = 2 ; z = 0 and z = 3. **(08 Marks)**

c. Show that electric field intensity is negative potential gradient. **(05 Marks)**

OR

4 a. The flux density $\overline{D} = \frac{r}{3}\bar{a}_r$ nC/m^2 in free space :

i) Find $\overline{E}$ at r = 0.2 m

ii) Find the total electric flux leaving the sphere of r = 0.2 m.

iii) Find the total charge within the sphere of r = 0.3 m **(07 Marks)**

b. State and prove Gauss divergence theorem. **(07 Marks)**

c. Derive an expression for continuously equation. **(06 Marks)**

Module-3

5 a. Determine whether or not the following potential fields satisfy the Laplace's equation:
i) $V = x^2 - y^2 + z^2$ ii) $V = r\cos\phi + z$ iii) $V = r\cos\theta + \phi$ **(06 Marks)**

b. Evaluate both sides of Stoke's theorem for the field $\overline{H} = 6xy\,\bar{a}_x - 3y^2\,a_y$ A/m, for rectangular path around the region, $2 \le x \le 5$, $-1 \le y \le 1$, $z = 0$. **(08 Marks)**

c. Explain the concept of magnetic potential. **(06 Marks)**

OR

6 a. State and prove uniqueness theorem. **(06 Marks)**

b. Two plates of parallel plate capacitor are separated by distance 'd' and maintained at potential zero and V_0 respectively. Determine,
i) Potential at any position between the plates
ii) Surface charge density on the plates
iii) Capacitance between the plates. **(08 Marks)**

c. Find the magnetic flux density at the centre 'O' of a square of sides equal to 5 m and carrying 10 A of current. **(06 Marks)**

Module-4

7 a. Derive an expression for force on a differential current element and find force experienced by conductor of 6 m long, lies along z-direction with a current of 2A in $\bar{a}_z$ direction, if $\overline{B} = 0.08\bar{a}_x$ T. **(07 Marks)**

b. Explain magnetization and permeability. **(07 Marks)**

c. Derive boundary conditions at the interface of two magnetic materials. **(06 Marks)**

OR

8 a. A point charge of $Q = -1.2$C has velocity $\overline{\upsilon} = (5\bar{a}_x + 2\bar{a}_y - 3\bar{a}_z)$ m/s. Find the magnitude of force exerted on the charge if,
i) $\overline{E} = -18\bar{a}_x + 5\bar{a}_y - 10\bar{a}_z$ V/m
ii) $\overline{B} = -4\bar{a}_x + 4\bar{a}_y + 3\bar{a}_z$ T
iii) Both are present simultaneously. **(07 Marks)**

b. Find the magnetization in a magnetic material where:
i) $\mu = 1.8\times10^5$ H/m and M = 120 A/m
ii) $\mu = 22$, there are 8.3×10^{28} atoms/m^3 each atom has a dipole moment of 4.5×10^{-27} A/m^2 and
iii) B = 300 μT and $X_m = 15$ **(07 Marks)**

c. State and explain Faraday's law of electromagnetic induction. Hence obtain Maxwell's equation in point form and integral form. **(06 Marks)**

Module-5

9 a. Derive Maxwell's equations for time varying fields, represent them in point form and integral form. **(08 Marks)**

b. Obtain relationship between $\overline{E}$ and $\overline{H}$ in free space. **(06 Marks)**

c. In free space $\bar{E} = 50\cos(\omega t - \beta z)\bar{a}_x$ V/m. Find the average power crossing a circular area of radius 2.5m in the plane $z = 0$. **(06 Marks)**

OR

10 a. Given $\bar{E} = E_m \sin(\omega t - \beta z)\bar{a}_y$ in free space, find $\bar{D}$, $\bar{B}$ and $\bar{H}$. Sketch $\bar{E}$ and $\bar{H}$ at $t = 0$. **(08 Marks)**

b. Explain wave propagation in good conductor with relevant equations. **(08 Marks)**

c. Wet marshy soil is characterized by $\sigma = 10^{-2}$ s/m, $\varepsilon_r = 15$ and $\mu_r = 1$. At 1 MHz whether soil be considered as conductor or dielectric. **(04 Marks)**

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